

Optimizing Burner Placement

A computational fluid dynamics study is providing insights into how burner placement affects the performance of thick-wall tunnel kilns.

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Everyone agrees that optimized burner placement in thick-wall tunnel kilns can offer substantial performance benefits, including improved flue gas entrainment ratios; enhanced temperature uniformity, reduced fuel consumption and lower nitrogen oxide (NOx) emissions. However, exactly what constitutes 'optimized burner placement' has been the subject of considerable debate over the years. While some plants prefer to mount burners flush with the hot face, others recess them in a tunnel or use venturi blocks to increase burner entrainment ratios and promote temperature uniformity and heat penetration into the hack.

At the request of one major brick manufacturer, Hauck recently performed a computational fluid dynamics (CFD) analysis of two different high-velocity burners at various burner insertion depths in a thick-wall, underdeck-fired tunnel kiln. The results of this study are providing valuable insights into how burner placement can affect overall kiln performance.

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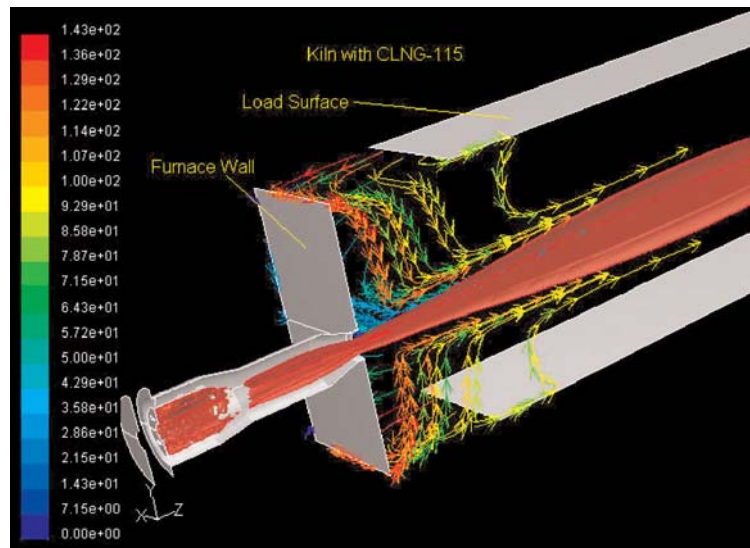


Figure 1 - Long-nose burner, flush mounted entrainment.

Analysis Details

The investigation compared the relative entrainment ratios (defined as the mass flow of entrained furnace gases divided by the mass flow of gases exiting the burner nozzle) and the temperature uniformities of two high velocity burners at different placements; a long nose burner with the discharge nozzle flush-mounted to the furnace wall hot face; and a conventional square block tile with the discharge nozzle recessed inside the furnace wall at 6, 12 and 19 in. With the exception of

burner tunnels, the furnace geometry was fixed for all cases. The distance from the hot face to the load was 8 in., and the burner was centered below the setting deck.



The model was developed using Fluent® CFD software and was based on the burners having nominally the same average discharge velocities at 10% excess air such that true comparisons of entrainment ratios could be made. In addition, all models included a furnace zone set-point temperature of 1,840°F as well as products of combustion, or a cross flow, from previous furnace zones. Further, the model was a snapshot in time of a steady state condition and does not account for the well-known positive effects of pulse firing.

Results

Figures 1-3 show the fluid particle path lines indicating entrainment flow for the flush mounted, 6-in. and 19-in. recessed cases respectively. As the fluid particle path lines indicate, substantial entrainment into the burner tunnel occurs even with the burner recessed the full 19-in.

Since the hack distance relative to the furnace hot face is fixed at approximately 8-in., entrainment ratio comparisons were made at a fixed distance of 4-in. or halfway between the hot face and hack. For comparison purposes, the entrainment ratio was further normalized by dividing by the flush-mounted long nose burner case at 4-in. The normalized entrainment ratios were 1.0 for the standard or flush mounted case and 1.93, 1.77, and 1.47 for the 6-, 12-, and 19-in. recessed cases respectively. The entrainment ratio was maximized at 1.93 with the burner recessed 6-in. in a tunnel equal in width and height to the burner block size. In fact, even the 12-in. and 19-in. recessed cases resulted in far more entrainment, 77 and 47% respectively, than the flush-mounted burner.

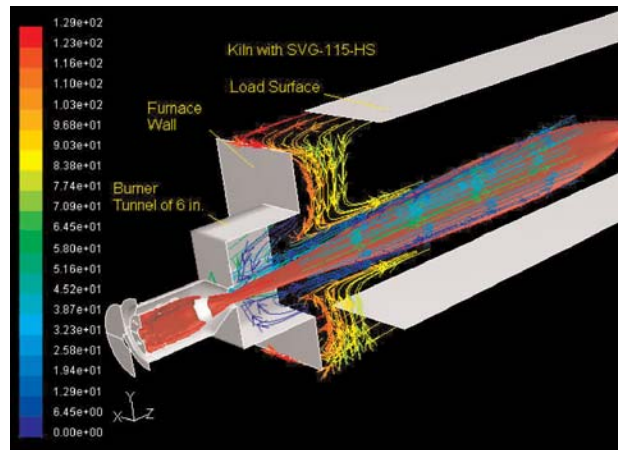


Figure 2 - Standard burner, 6-in. tunnel entrainment

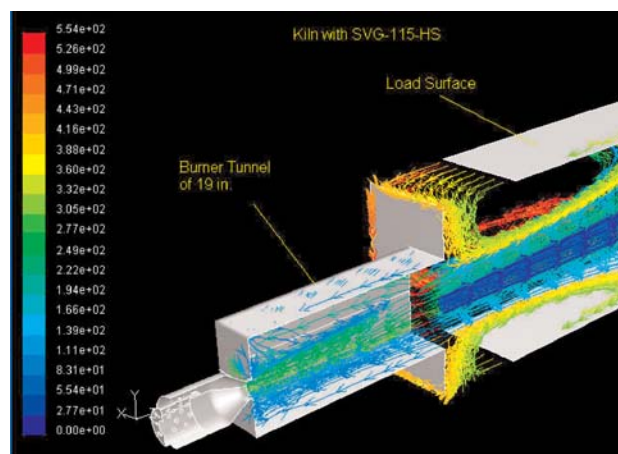


Figure 3 - Standard burner, 19-in. tunnel entrainment

However, the effective temperature distribution in the furnace and load must also be considered. The resulting temperature distribution on the bottom surface of the load for the flush-mounted case is shown in Figure 4. The flush-mounted burner installation results in the hottest load bottom surface temperature of 1,810°F substantially to the right of center with a cool spot near the burner of 1,690°F for a load temperature delta of +/- 60°F.

Figure 5 shows the extreme or 19-in. tunnel length recessed load temperature profile with the peak temperature now near the tunnel discharge and equal to 1,910°F, and a minimum hack surface temperature of 1,630°F farthest from the burner for an overall temperature delta of +/- 140°F.

Figure 6 shows the 6-in. recessed burner which results in a load peak temperature of 1,820°F in the center of the hack and minimum temperature of 1,750°F near both ends of the hack resulting in the best overall temperature delta of +/- 35°F.

Figure 7 shows a side temperature profile of the 6-in. recessed burner. A desirable heat release pattern and overall flame size for the furnace geometry in question are evident. In addition, a 14% reduction in NO_x was predicted with the 6-in recessed burner case versus the flush mounted burner due to increased entrainment rates.

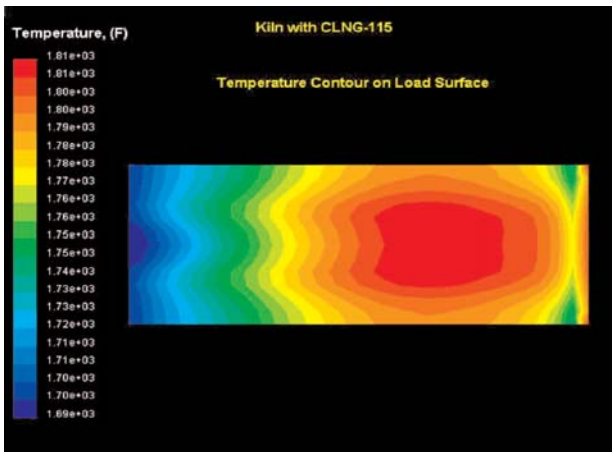


Figure 4 - Long-nose burner, flush-mounted load temperature profile

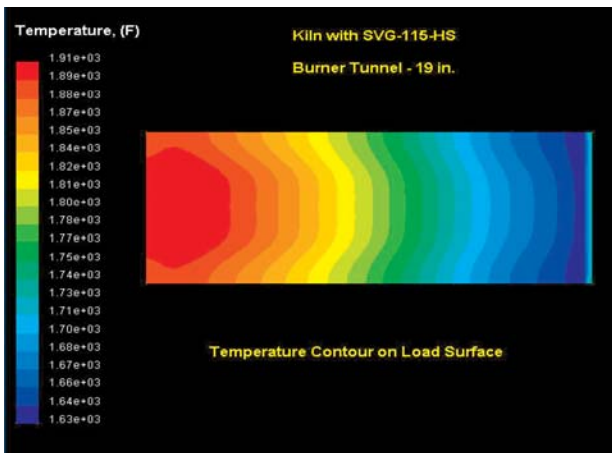


Figure 5 - Standard burner, 19-in. recessed tunnel load temperature profile

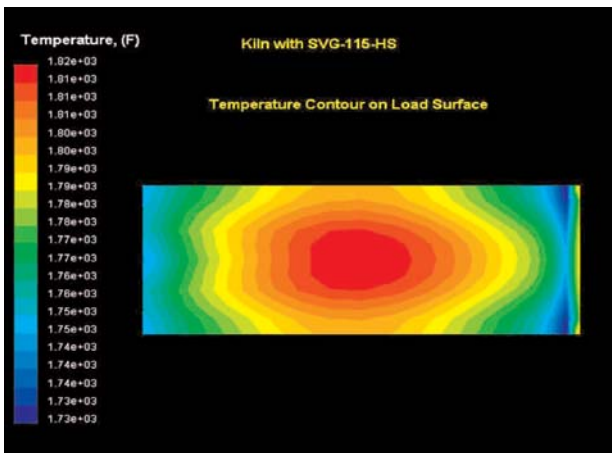


Figure 6 - Standard burner, 6-in. recessed tunnel load temperature profile

Conclusions

In this study, the 6-in. recessed burner provided peak entrainment ratios near the hack, as well as the most uniform hack surface temperature distribution. These results can be broadly interpreted to mean that a 6-in. recessed burner is ideal in all thickwall tunnel kilns; however, caution must be exercised when applying results from one kiln analysis to other kilns. For a wider kiln than the one modeled here, a flush-mounted burner might provide better temperature uniformity than a recessed burner. Other factors that can affect performance include the tunnel dimensions (especially with oversized tunnels), and the hack or load distance in both the horizontal and vertical planes from the burner nozzle.

To ensure completely optimized burner placement - including optimized flue gas entrainment ratios, enhanced temperature uniformity, reduced fuel consumption and lower NOx emissions - manufacturers should carefully evaluate all kiln parameters and obtain advice from an experienced kiln/burner professional.

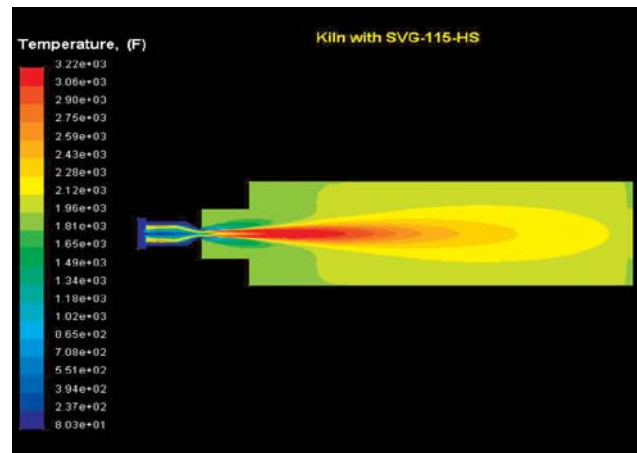


Figure 7 - Standard burner, 6-in. recessed tunnel temperature profile

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